Title: Toward the Parameterization of Inhomogeneous Mixing in Cloud Resolving Models: Results from a PDF Study

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Abstract:

Currently, the accurate prediction of cloud droplet number concentration in cloud resolving, numerical weather prediction and climate models is a formidable challenge. The process of inhomogeneous mixing, in which droplets evaporate completely in centimeter-scale filaments of sub-saturated air during turbulent entrainment [Baker et al., QJRMS, 1980], is unresolved at even cloud-resolving scales. Despite the large body of observational evidence in support of the inhomogeneous mixing process affecting cloud droplet number [most recently, Brenguier et al., JAS, 2000], it is poorly understood and has yet to be parameterized and incorporated into a numerical model.

In this talk, we investigate the inhomogeneous mixing process using a new approach based on simulations of the probability density function (PDF) of relative humidity during turbulent mixing. PDF methods offer a key advantage over Eulerian (spatial) models of cloud mixing and evaporation: the low probability (cm-scale) filaments of entrained air are explicitly resolved (in probability space) during the mixing event even though their spatial shape, size and location remain unknown.

Our PDF approach reveals the following features of the inhomogeneous mixing process during the isobaric turbulent mixing of two parcels of clear and cloudy air:

1. The degree of total droplet evaporation depends linearly on the mixing fractions of clear and cloudy air and logarithmically on Damköhler number (Da)—the ratio of turbulent to evaporative time-scales.

2. Our simulations predict that the PDF of Lagrangian (time-integrated) supersaturation (S) goes as S^{-1} at high Da. This behavior results from a Gaussian mixing closure and requires observational validation.

3. Our PDF approach can be used to parameterize inhomogeneous mixing in cloud resolving models (via look-up tables) if an additional model that predicts subgrid cloud fraction is devised.